Chapter 5
Darwinian Evolution of the Human Body and Culture

Jerzy Dzik

Abstract The fossil record of the anatomical evolution of the human lineage shows that it was very slow and gradual. While changing their habitat from a primeval forest to the unpredictable environment of savannah, our animal ancestors had to change their ecological strategy. As a result, fertility increased, childcare was prolonged, and sedentary family life developed. A hormonal mechanism of filial and sexual imprinting supported these changes by strengthening emotional family ties. This means that such aspects of human biology as sexual behaviour, family love, herd instinct, and feeling of ownership are inherited after our animal ancestors and have a very ancient evolutionary history. The human brain size increase does not necessarily express the development of intellectual abilities but is rather a thermoregulatory mechanism connected with persistence hunting. The intellectual potential of the large brain emerged long after its evolution had been completed. A powerful tool for scientific interpretations of this paradox is offered by the application of the Darwinian way of reasoning to the evolution of human culture, resulting in the selection of ideas. Cultural evolution is cumulative, and some institutions invented by this process may partially liberate humans from the limitations of their biological heritage.

Keywords Behaviour • Ethics • Hominin • Imprinting • Phylogeny

Introduction

Science does not guarantee access to truth. In this respect it can hardly compete in self-confidence with religion or art. The only ambition of scientists conscientiously doing their job is to approach the unknown objective reality (which is assumed to exist) as closely as possible. The result is presented in a form of its most

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parsimonious description. Occam's Razor has been borrowed from theology to be applied at this stage, but science is distinct from theology in requiring the potential testability (or even falsifiability) of its claims by empirical evidence. This implies severe limits both on the permitted scientific interpretations of human culture and on those living beings which created it. Bearing in mind these restrictions I will try to show in this paper that it is possible to construct an internally consistent explanation of the uniqueness of humanity using exclusively the method of science.

To explain the presence of humankind on Earth without employing any supernatural causes means invoking the theory of evolution. But the term 'theory of evolution' as currently used has two meanings. It may be understood as a historical description of the process of evolution. Such a narrative is not a scientific theory in its strict methodological sense. The history of the natural world is unpredictable to the same degree as the history of human civilization. And for the same reason, which was pointed out and explained in terms of the natural sciences by Schrödinger (1944) and of the humanities by Popper (1957). Any description of the course of evolution belongs to the historical sciences in the strictest sense. It cannot be falsified by comparing predictions with observations of results because prediction is not possible. The only available testable way of reasoning is back in time, by retrodiction (e.g. Wächtershäuser 1992; Dzik 2005).

The second meaning is Darwin's theory, offering causal explanation of the phenomenon of evolution. In its present understanding it claims that if selection is imposed on a set of objects that are able to increase spontaneously the strictly inherited variability in their efficiency in using resources for reproduction, then the variability changes its pattern in every successive generation according to selection pressure. Actually, such reasoning has been widely used in breeding of animal breeds and plant varieties for centuries. There have been countless opportunities to falsify Darwin's theory but all have failed. It is a regular, predictable and potentially falsifiable theory of the natural sciences, as long as the selection pressure remains stable and the genetic pool of a population is closed. Unpredictability emerges with long-term changes of natural selection and random modifications of genomes in geological time scales. But it is not Charles Darwin who discovered the phenomenon of biological evolution as such.

The Evidence for Evolution

Fortunately for us, the global circulation of living matter is not uniform and locally it may be suspended, even for a billion years. This enables evolution to be recorded in rocks. To decipher such records we rely on the basic aspect of sedimentation: mineral grains settle from suspension in water or air and accumulate at the bottom of the sea, lakes, and rivers, or in valleys on the land. As a result layers of clay, sand, or gravel are the oldest at the base and youngest at the top of the succession. Sediments transformed into hard rocks may be elevated, folded or even reversed during the formation of mountains but their original disposition is changed only rarely.

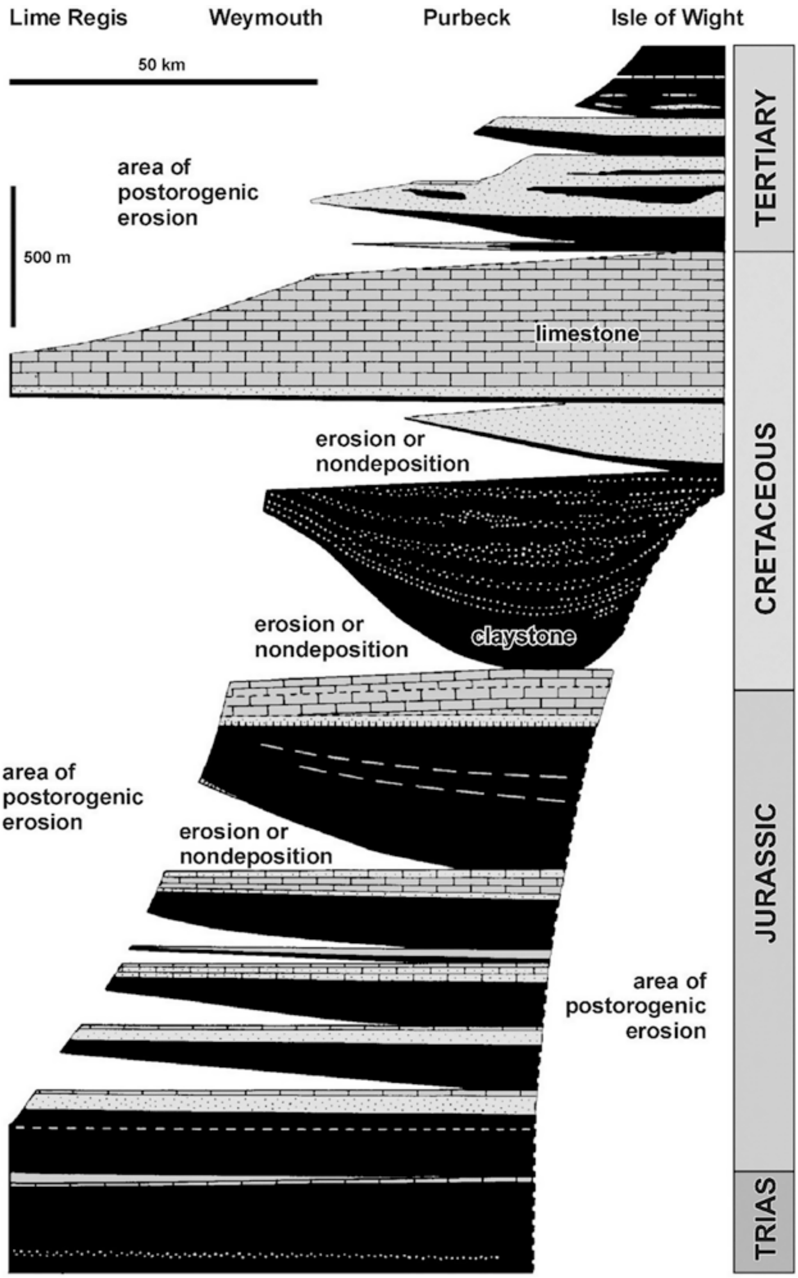

Fig. 5.1 Geological section across the English Channel showing completeness of the record of geological time in sedimentary strata (Based on House 1989)

Sedimentation in one place requires erosion in another place. Erosion makes the geological record of events in the deep past locally incomplete (Fig. 5.1). Generally, the succession of rocks originating in the deep sea offers a more reliable and less punctuated picture of prehistory than the succession of strata deposited on land or in shallow seas. This is why mostly the record of events in open seas is used as the reference standard for the geological time scale.

Obviously, it is not easy to find a complete rock succession covering a time span necessary to record the process of evolution. But such evidence was available already before Charles Darwin published his theory explaining its mechanism. One of the first examples was published a decade earlier, in 1847. The zoologist Edward Forbes, a member of the research expedition to the Aegean Sea on board the *Beacon*, while visiting the lacustrine strata of the Pliocene age on the Kos Island noticed an evolutionary change in snail shells collected from successive rock beds (Willmann 1978; Büttner 1982). More recent stratigraphically dense sampling supported his interpretation and increased the resolution of the record (Fig. 5.2).

Now it seems reasonable to assume that populations characterized by samples of fossils from neighboring beds, close to each other in time, space and morphology, show genetic continuity. Minor differences between nearby samples are apparently accumulated until a completely different morphology eventually emerges.

Numerous such examples of evolutionary change have been published since the Edward Forbes paper, and the methods of studying them have significantly improved. In strata deposited in the open sea, the fossil record of a lineage may continue for millions of years without any gaps. Some kinds of fossils are common enough, and easy to extract from the rock, to allow the description of population variability in samples of thousands of specimens. Especially useful in this respect are conodonts – extinct chordates similar to the present-day lampreys. These distant relatives of ours had a complex mouth apparatus composed of several phosphatic teeth that can be recovered from limestone rock by dissolving it in acetic acid. One needs only a series of samples to arrange data into an evolutionary succession. In most cases the geological time span from their immigration to disappearance is too short to show their evolution. Only for species that stay in place for a long time is the evolutionary change apparent (Fig. 5.3). The morphological change is mosaic, in the sense that each anatomical trait evolves independently in its own way and rate.

The evolution of animals results mostly from modifications of the development of individuals, that is, their ontogeny. The ontogeny of conodonts can be traced day-to-day owing to regular increments of their mineral tissue, easily discernible under the electron microscope within the tooth (element) basal cavity (Dzik 2000). They closely resemble increments in the enamel of human teeth, which preserve a daily record of our childhood. In some conodonts, the juvenile tooth suddenly changed its shape, probably at the end of a larval stage. Counting the daily increments shows that the evolutionary change in size of the 'larva' was gradual and due mostly to the increase in the mineral tissue secretion rate, not by extending the time of secretion (Fig. 5.4). Such studies performed on fossils of organisms representing different systematic groups, of various geological age and ecological preferences, invariably show very slow rates of change, requiring millions of years (Dzik 2008). Rather

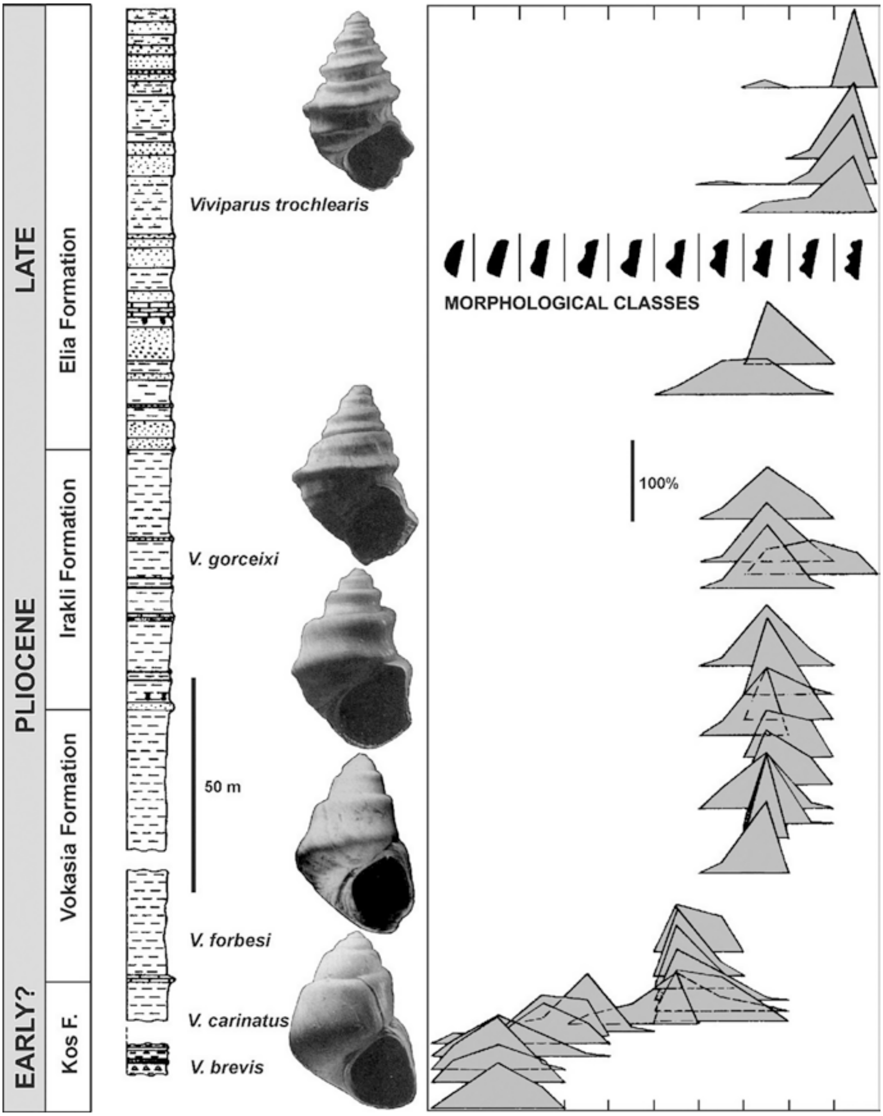

Fig. 5.2 Change in relative frequencies of *Viviparus* snails conch classes across the stratigraphic succession of Pliocene strata on the Island of Kos (Based on Willmann 1978 and Büttner 1982)

unexpectedly, the evolution rate was highest in environments that were rather stable.

Conodonts were not unique in their mode of evolution. Although the fossil record of land animals is not as accessible as that of conodonts, it is possible to compile such data even on the largest of mammals, e.g. the mammoth. Unlike other elephants, it ate mostly grass. Grass is of low energetic value and contains microscopic

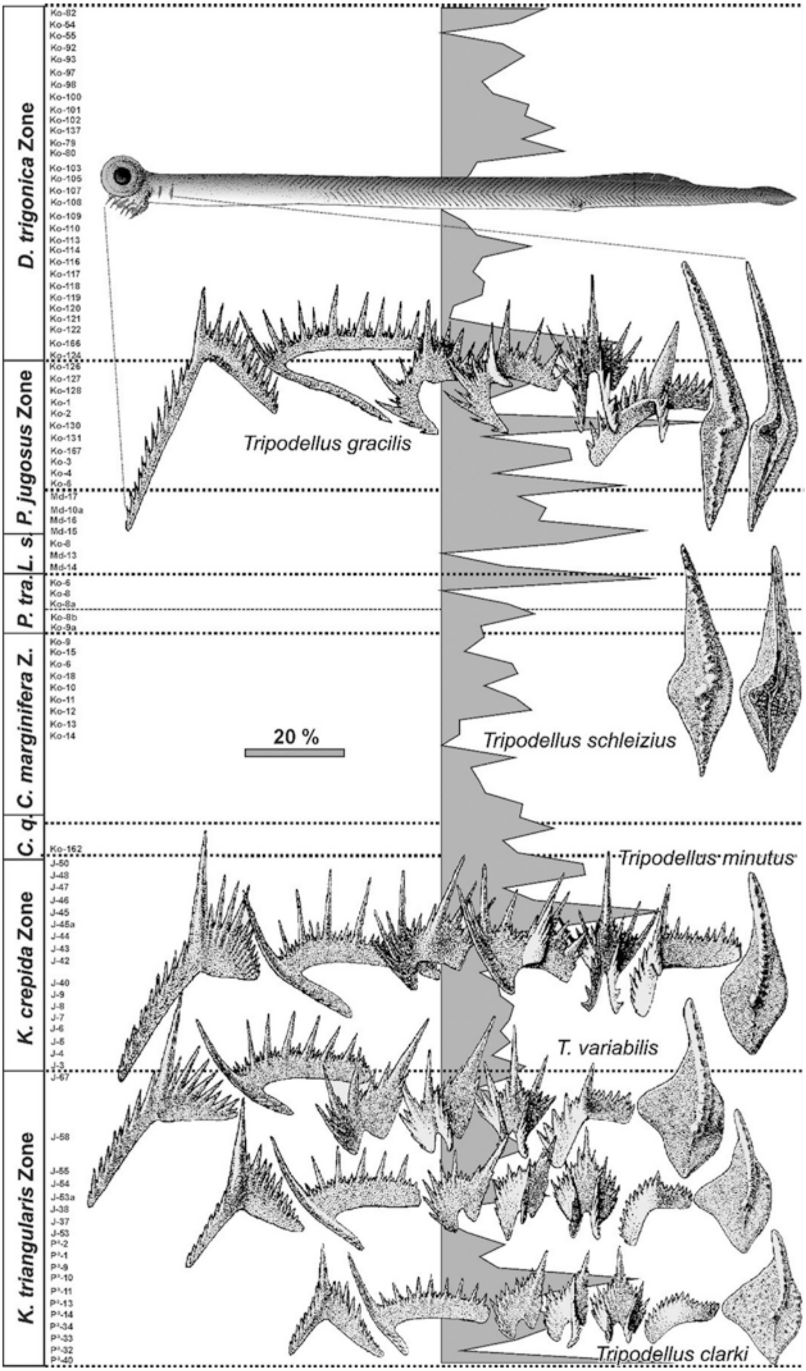

Fig. 5.3 Persistent occurrence of the conodont lineage of *Tripodellus* in central Europe recorded in the Devonian strata at the Kowala Quarry near Kielce, covering the time span of about ten million years. Per cent contribution of the apparatus elements of a species to whole conodont samples is shown (Based on Dzik 2006)

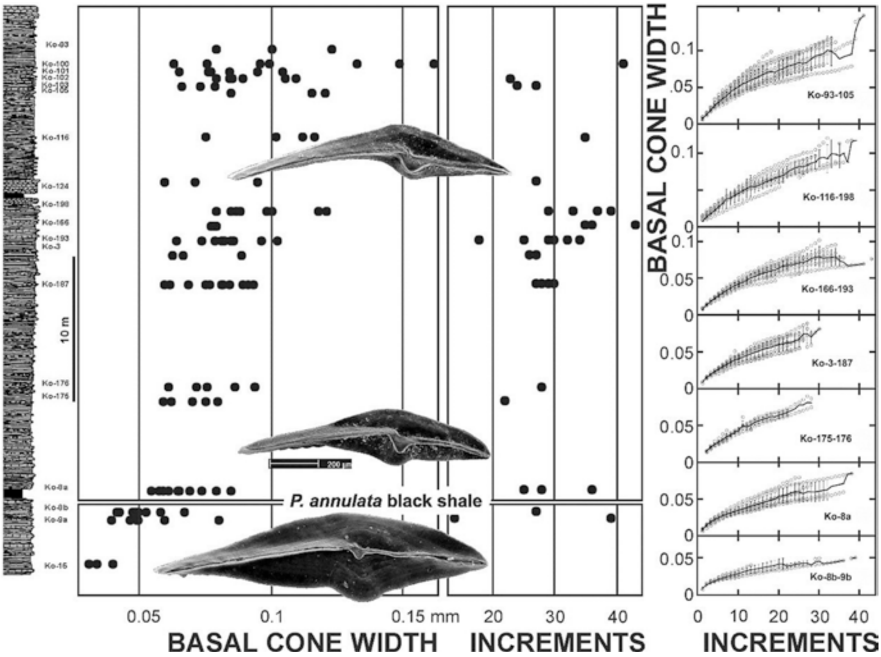

Fig. 5.4 Daily record of gradual evolution of ontogeny recorded by one of the *Tripodellus* apparatus element type in the Devonian strata at the Kowala Quarry, for about five million years (Based on Dzik 2006)

silica concretions (microliths) that abrade teeth. As an adaptation to this kind of food, the cheek teeth of grass-eating mammals develop a complex structure with numerous transversely elongated cusps that change into rows of enamel blades separated by depressed areas of worn dentine. It took almost three million years of evolution for elephants to develop the teeth morphology typical of the mammoth (Fig. 5.5). The rate of evolution was as slow as in case of conodonts and of many other plant and animal lineages having a reasonably complete fossil record. Large land animals evolved in the same way as marine ones. Apparently, this applies also to the evolution of humans.

Man's Place in Evolution

We owe our position in the zoological classification of animal species to Carl Linné (Linnaeus), who in his *Systema Naturae* in 1735 included man, together with apes, in his taxon Anthropomorpha. Interestingly, in later editions of his treatise, our binominal name was not *Homo sapiens*, but *Homo diurnus* (daily man) to distinguish us from the orang-utan, referred to as *Homo nocturnus*. Although initially the

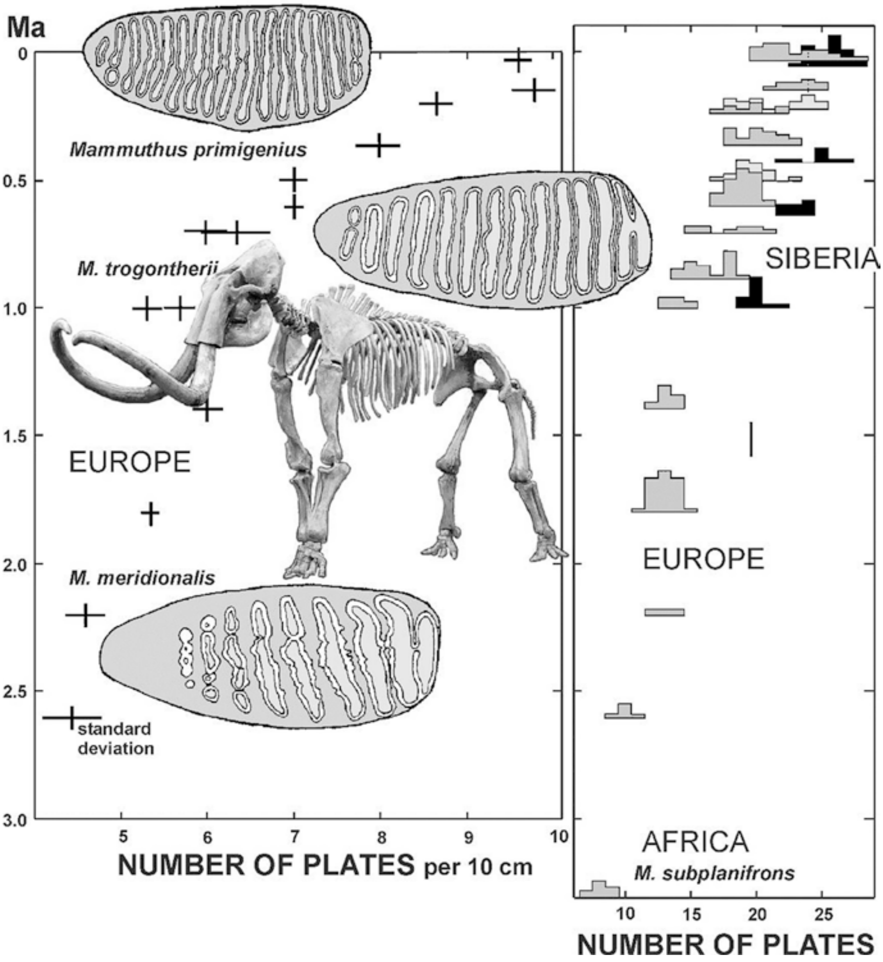

Fig. 5.5 Evolution of the mammoth lineage (Based on Lister and Sher 2001. Note that the ancestors of mammoths lived in Africa and that Siberian populations were ahead in developing new adaptations that spread later to Europe)

idea to classify humankind together with apes met some opposition from religiously-motivated naturalists, today no respected biologist questions Linnaeus' proposal.

The argument in favor of placing humankind in the zoological system of classification that probably appeals the most to laymen is the profit we make from using animals as models in biomedical research. They make experiments on humans unnecessary and offer adequate approximations of our physiology. It seems meaningful that the most widely used experimental animals are rodents: mice, rats and guinea pigs. There are several reasons for their career as laboratory animals, including the importance of their position on the evolutionary tree. They are our close relatives, and this makes their physiology similar to human. Of course, apes are even closer, but they are too similar to humans in their appearance and behavior, which makes their inhuman treatment difficult to accept. It appears that evolutionary relationship matters even to those people who do not believe in evolution.

No doubt most aspects of our anatomy have resulted from the arboreal life of our early ancestors. These adaptations to life in trees originated consecutively, as a case of mosaic evolution. The first arboreal adaptation was the prehensile function of fingers. It removed a weight limit from the primate body, unlike other arboreal mammals that depend on claws in clinging to the tree bark. Grasping a twig with fingers may be painful if sharp claws meet skin. To protect the hand, the finger-tips of prosimians enlarged and eventually claws changed into the nails of monkeys, easily breaking off. Monkeys gracefully jump from branch to branch, or even between trees. This requires stereoscopic vision, with both eyes oriented in the same direction and their fields of vision overlapping. Stereoscopic vision impairs the ability to look around and promotes rotation of the head on a vertical neck. The prominent snout of our lemur-like early arboreal ancestor was another inconvenience, as it obstructed the view of eyes. This enforced a gradual reduction of jaw length and improved protection of the eyes with a bony postorbital septum (Fig. 5.6).

Unlike opposing fingers and stereoscopy, bipedality is a recent locomotory adaptation that developed in the hominid lineage probably soon after the change of habitat from tropical forest to savannah (White et al. 2009). Bipedal locomotion can be inferred from the bones of the foot, but the most convincing evidence that our ancestors were already truly bipedal 3.8 million years ago comes from the tracks preserved in a cemented tuff from Laetoli in Tanzania (Leakey 1979). Skeletons recovered from strata of similar age from the same region show that the brain of the trace-maker was of similar size to that of a chimpanzee. This means that intellectual abilities have nothing to do with bipedality. If not the pressure on mental abilities, which other selection factor forced our distant relatives to stand on their feet? This is a highly debatable issue, but among explanations offered by various authors, that of C. Owen Lovejoy (1981) appeals to me the most.

According to his hypothesis, the triggering factor was the ecological shift from the stable conditions of life in the tropical forest to the unpredictable conditions of the savannah. Instead of the low reproduction rate typical for ecological specialists inhabiting the rain forests, higher mortality in the new oppressive environment had to be compensated by increased fertility. This required additional investment by delivering more and more offspring fed with milk long after delivery. A new aspect was an additional expense of energy in the extended childcare. Mothers with numerous toddlers could not move efficiently. The final result was a sedentary family and cooperation between sexes. But how to enforce permanent ties between members of the family characterized by a division of tasks? Apparently this was the neurophysiological phenomenon of love triggered by hormones, a mechanism with a long evolutionary history.

The evolution of sexual behaviour in animals can be traced along branches of the phylogenetic tree. Sexual contact of even the most primitive unicellular eukariotic organisms requires the ability to identify individuals of the other sex and distinguish them from prey or enemy. This distinction is based on chemical signals recognized

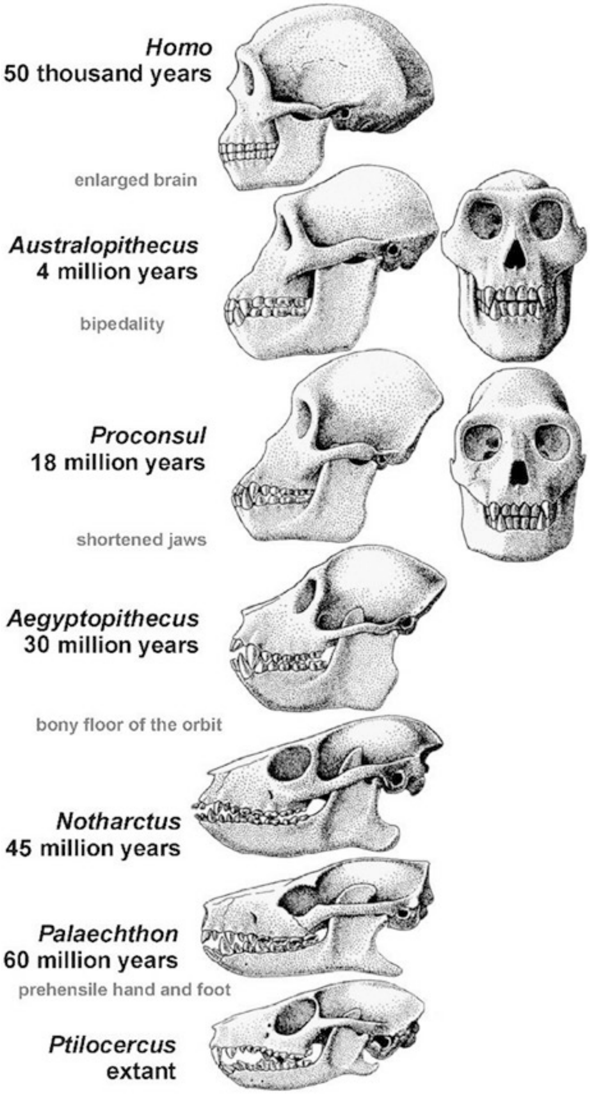

Fig. 5.6 Dating of evolutionary changes in morphology of the primate skull mostly connected with stereoscopic vision

by receptors in the cell membrane. In this way, gametes of multicellular animals dispersed in water join together into zygotes. In many unrelated animal lineages males and females recognize themselves, join together and synchronize expulsion of gametes (see, e.g. Emmons and Lipton 2003). It is almost certain that our Devonian fish and amphibian ancestors also did this, like today's frogs. Selection promotes such behaviour to reduce the waste of living matter in eggs and sperm. It remains unknown how the whole series of necessary actions are recorded in the genome, but it is clear that sexual behaviour is heritable and that it evolved. It is not precisely determined when our ancestors became independent of water in their reproduction, because fossil bones do not offer such evidence. However, this definitely happened before the split of evolutionary lineages leading to present day reptiles and mammals, that is before the end of the Carboniferous. The reptilian embryo does not depend on the external water environment owing to supplementation of the egg envelope with embryonic membranes (amnion and allantois) but the act of fertilization must still be performed in water and before the egg (more precisely: embryonic) membranes and shell are formed. Copulation with penetration and internal fertilization is a must for a land animal. This requires an anatomical adaptation, that is a copulatory organ (Kelly 2002), and also hereditary knowledge how to use it. It means that the human sexual behaviour has evolved over more than three hundred million years.

Some information about the more recent evolution of human sexuality can be inferred using the methods of sociobiology. Human males are significantly larger than females and the present-day pattern of dimorphism seems have continued for at least 430 thousand years (Arsuaga et al. 2015). Such size disparity characterizes mammalian species, in which fighting for control of a harem occurs. This may mean that our ancestors were polygamous and the present predomination of monogamy is a cultural invention imposed on the organization of society. A rather unusual aspect of human sexual dimorphism is the attractiveness of females. Perhaps this evolved as a measure to develop prolonged ties of the male with a female breeding his children and dependant on the food resources provided by him. To posit that human sexual behaviour is of a purely biological nature probably does not evoke disagreement. Emotionally more sensitive is the issue of maternal love, considered to belong to the class of higher moral values. But it would be hard to remove it from biology as well.

Maternal care can be found in virtually all higher rank groups of animals. In mammals, it is mostly expressed in feeding progeny with milk. In the case of the most primitive of mammals that has survived to our day, the Australian platypus or echidna, juveniles lick the glands which secrete milk. To enable them to do this the female has to intentionally expose her belly. In placental mammals sucking requires even more activity from the female. Again, this is a hereditary behaviour recorded in the genome that developed and was improved during almost two hundred million years of mammalian evolution. It is well known how hormones trigger particular aspects of maternal care behaviour, although its exact correspondence to sequences of nucleotides in the genome remains to be determined.

Permanent family ties, a stationary home and transportation of food obtained by males through hunting are factors that controlled the early evolution of the human lineage, according to this interpretation. It is widely questioned as a support of traditional conservative values. But one may argue that if these values are conservative and truly out of date, they are still likely to describe ancient human society properly in its biological aspects, before sophisticated cultural regulations developed. Even more emotionally troublesome is the biological status of those emotions that provide inspiration to the most subtle aspects of human cultural activity, to poets, composers or painters: the emotion that keeps a wife together with her husband and children. I mean love in its most eternal, not sexual form.

It is well known that hormones enable the initiation and manifestation of some ‘higher’ emotions. Since the classic observation of Edvard Westermarck, this is referred to as ‘imprinting’. Love of parents is imprinted at the first contact with them, or with somebody who was in their place at the proper time (Bolhuis 1991). Probably the same mechanism results in ‘love at first sight’ and perhaps also in homosexuality (e.g. Coria-Avila 2012). But prolonged contact with relatives make them sexually neutral. All this is regulated in the brain, which does not need to be enlarged and human in nature to perform such duties. There is no way to avoid admitting that these phenomena belong to our animal heritage.

The physiological mechanism of love is apparently the same in humans as in other mammals, including the American prairie vole, in which this mechanism was recognized first (Winslow et al. 1993). It is controlled by simple biochemical molecules, the oligopeptide hormone oxytocin in females and vasopressin in males, which have their evolutionary origin as regulators of the water balance of the organism (Gwee et al. 2008). The physiological mechanisms of their influence on the central neural system is relatively well known, and resembles the action of drugs. Its genetic basis and evolution remain to be solved.

To secure humankind a place in our zoological systematisation, one needs a formal species rank name for it. This may not be easy in respect to fossils.

The Human Species

An approach widely used in palaeontology is to subdivide arbitrarily a continuous series of evolving populations into segments, referred to as chronospecies. In every time slice the chronospecies is a biological species. The conventional limit for the temporal extent of a chronospecies is such that the difference between its geologically oldest and youngest populations is such as between two species living today which are closely related to each other. The concept of species and chronospecies currently accepted by most (but not all) biologists developed in connection with taxonomic methodology long before the evidence of population genetics clarified the issue. But both the traditional typologic approach and biological species concept refer to the type specimen (holotype) as the name-bearer (Simpson 1940). Our species also has a formally selected type: Carl Linné himself (Stearn 1959). It was an unnecessary action, considered a joke by most researchers, but potentially useful as an indication that the typical member of the species *Homo sapiens* belonged to a population living in Scandinavia in the late Holocene.

The question emerges, which of the fossil populations of our ancestors are different enough from the populations of present-day Swedes, Eskimos, and Khoikhoi people of South Africa to represent a segment of our branch of the evolutionary tree deserving a different name. There were several waves of expansion of our human ancestors from Africa to Europe, and retreats with every glacial epoch. Only those of modern man immediately preceding the last Weichselian glaciation are of importance to the present-day diversity of races and ethnic groups. Some of these tribes, for instance the Pygmy people of Africa, have lived in isolation for more than forty thousand years, but no genetic barrier between them and other human populations has developed yet. Ancestors of the present-day Aborigines invaded Australia at the same time as Neanderthals lived in Europe (Adcock et al. 2001; Bowler et al. 2003). But there was not enough time to develop their (or Neanderthals') genetic isolation from coeval humans from Africa and Asia.

Fossils show that populations more than one hundred thousand years old are easily distinguishable from modern ones. Such a conclusion requires a search for a name for the (chrono)species they represent. The name-bearer (holotype) with a nomenclatorial priority within this age frame is the skullcap of *Homo erectus* from Trinil on the Java Island. The sediment from Trinil, in which shells collected by humans were also found, dates from 0.54–0.43 million years ago (Joordens et al. 2015). This offers a lot of freedom in deciding at what level of the evolutionary continuum the name should change from *H. sapiens* to *H. erectus*. But even more problematic is the formal delimitation of the beginning of the *H. erectus* segment of evolution. In a bed dated approximately 1.63 million years ago at Koobi Fora, Kenya (Lepre and Kent 2015), a skull has been found with a brain volume of about 850 cm^2, classified as *Homo ergaster*. The holotype of this species is a mandible from the same locality dated 1.5 million years ago. A similar age of 1.8–1.6 million years is attributed to the Mashavera basalt underlying the bed at Dmanisi, Georgia, several skulls from which demonstrated the great variability of early humans (Lordkipanidze et al. 2013). There is no way to decide on objective scientific grounds whether *H. ergaster* should be synonimized with *H. erectus* or not.

The name *Homo habilis* has been popularized as the direct 'ancestor' of *H. ergaster* (and *H. erectus*). Its holotype is a lower jaw of an immature individual found in the Olduvai Gorge, Tanzania, dated 1.75 million years ago. The most complete probably conspecific adult skull found at Koobi Fora, which dates to probably a little more than 1.87 million years ago, offered a reliable estimate of the adult brain size of 510 cm^2. Moreover, the holotype of *H. habilis* co-occurs with the holotype specimen determined as representing another species (and genus) *Australopithecus* (=*Zinjanthropus*) *boisei*, and the same co-occurrence characterizes the Koobi Fora. The Dmanisi sample calls for reconsideration of the value of differences between them.

The genus *Australopithecus* was originally introduced for the species *A. africanus* from South Africa. Unfortunately, the cave deposits in which the juvenile holotype skull was preserved were destroyed by mining before its exact age could be determined. Based on associated animal bones, it is estimated to be 2.3–2.8 million years old. Similar problems are connected with the dating of the holotype of *A.* (=*Paranthropus*) *robustus*. Only findings of more specimens, enabling an estimation of the range of population variability, could end the dispute whether these are truly different co-occurring biological species and what is the status of the oldest 'species' of *Australopithecus*.

Thus, the ‘hominin species’ is nothing more than a name applied by anthropologists to fossil bones or to DNA extracted from them (e.g. Prüfer et al. 2014). Nothing like the ‘origin of *Homo sapiens*’ ever happened. Instead, one may say that the name *Homo sapiens* is applied to a set of present-day populations that are able to interbreed and to some of those from the past that are believed to be in genetic continuity by inheritance.

After achieving full bipedality the skeletons of our ancestors evolved further towards their higher locomotory efficiency, but these were rather minor anatomical changes. The most spectacular evolutionary transformation was that of the brain.

Evolution of the Human Brain

Our brain started its evolution towards being different to that of apes not before three million years ago (Fig. 5.7). The fossil record of its evolution is similar to that of the Kos Island snails mentioned above: that is, the distribution of measurement in any time slice is unimodal, and ranges of variability in each two neighboring time slices strongly overlap. Such close correspondence between neighboring slices may be interpreted as a genetic continuity in populations represented by them. Apparently, our evolution was very slow and gradual, and its course was rather smooth. The presence of more than just one biological species of humans in any geological time slice is not likely (Henneberg 2006).

The traditional belief is that enlarging the brain volume correlates with an increase of mental abilities. This does not need to be true. The only available basis for estimating the ability to use brain powers in extinct animals are fossilized traces of their behaviour. In the case of humans, this refers mostly to the development of tool-making technology. Animals rarely use tools for making or using another tool, and the invention of such meta-tools is considered the marking point for the origin of the human-level mind. Stone tools can be made only with the application of a meta-tool, and their appearance in the fossil record may be used as evidence of mental abilities higher than those characterizing our animal ancestors. The oldest probable stone tools are 2.6 million years old: unquestionable finds are dated at 1.76 million years (Lepre et al. 2011). This is the time when the mean value for the brain cavity volume started to slowly increase. The correlation of subsequent achievements of human culture with the rate of brain volume increase is poor, however. It took two million years for human culture to start its virtually explosive development. This was long after the brain reached its maximum size. Another explanation for this phenomenon is required.

A possibility that deserves serious consideration is the connection of brain volume increase with persistence hunting, a peculiar way to kill game animals by chasing them over long distances. The prey is pursued until it is exhausted and eventually dies, because of the brain overheating (Bramble and Lieberman 2004). Surprisingly, humans are tougher in this respect than savannah ungulate animals. Fiałkowski (1978, 1986) argued that we owe this to the large brain volume, with many redundant

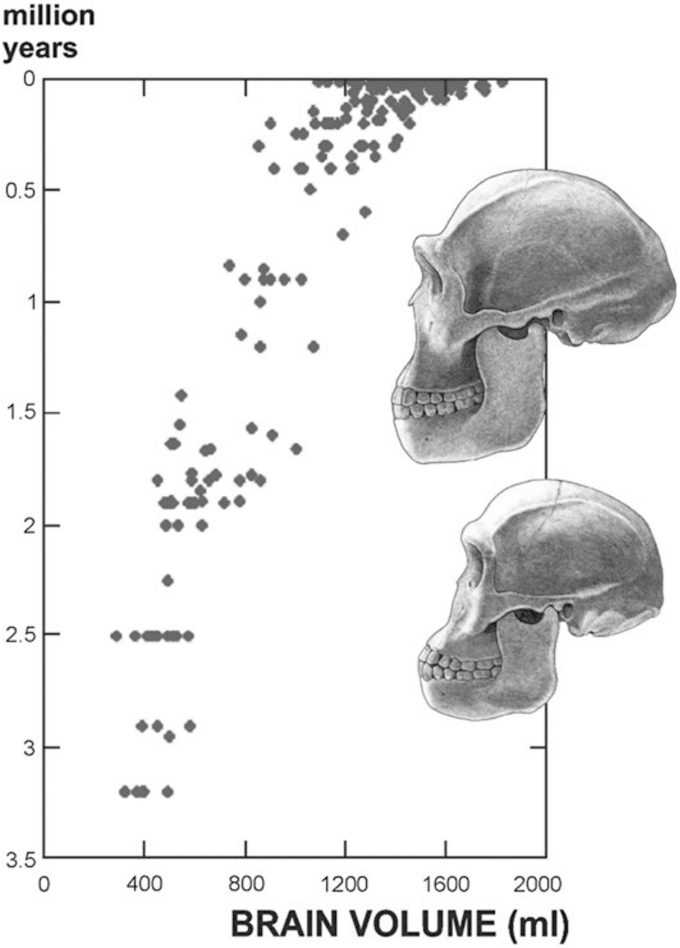

Fig. 5.7 Evolutionary increase in volume of the human brain as documented by the fossil evidence (Based on Matzke 2006)

neurons and interconnections. Their local damage does not impair function of the brain as the whole. Moreover, a lot of glia between neurons (typical for large-size brains) helps in heat dissipation. The first geographic expansion of *Homo erectus* initiated about two million years ago is marked by reaching the Caucasus before 1.8 million years, and more than half a million years ago the Indonesian islands and central China. Meanwhile, a global climate cooling initiated periodic glacial epochs, which imposed limits on the northward migrations of faunas.

Human evolution was continuous in time and space, which means that palaeontology cannot specify the time of the origin of humanity. This is not because it is unknown, but because of the very nature of biological evolution. However, our mind was designed to categorize discrete units in the surrounding environment that can be classified, not to see continuity between them. We rarely see how these objects change in time, and the perception of such change causes discomfort rather than giving satisfaction. We search for clear-cut boundaries; and apart from human evolution, this refers also to embryonic development.

The Beginning of a Human Individual in Ontogeny

Knowledge of early human development is a surprisingly new achievement of science. According to the traditional faiths, life is transferred from generation to generation with the sperm; woman only incubates it. The discovery of the mammalian egg was published as late as in 1828 by Karl E. von Baer, and it took several decades for his discovery to became widely appreciated (Betteridge 1981). Since that time the progress of science reached the level of enabling generalizations that are even more difficult to swallow. One such general truth of biology is that reproduction is in principle asexual.

In land plants and many algae fertilization occurs at the beginning of the dominant diploid stage (sporophyte) in their life cycle, but the act of reproduction by dispersion of spores takes place at the end of this stage. Not only plants but also many animals may reproduce without entering sexual processes. Both parthenogenesis, that is a cleavage of the egg without fertilization, and clonal propagation, that is formation of a new individual from somatic cells, are widespread among animals (even reptiles). In fact, clonal propagation by fission of the embryo is a norm in many mammals. In the normal development of armadillos, double fission of the embryo results in quadruplets (Enders 2002). Such is also the origin of monozygotic twins in other mammals, including *Homo*. If fission occurs early enough (after 2–8 days), normal foetuses of morphologically identical twins develop (Corner 1955; Gardner 2014). If it happens too late, then conjoined (‘Siamese’) twins are formed. It was shown by Andrzej Tarkowski (1961) that until a certain stage in development is achieved, even genetically different embryos can be unified in a healthy individual (genetic chimaera). There is no way to avoid the conclusion that individuality is not necessarily a result of fertilization. This means that biology cannot determine when exactly the human individual originates.

Another general truth of biology is that the only purpose of sex is recombination of genes. The phenomenon of sex has nothing to do with reproduction – in fact, as a result of the unification of gametes the number of individuals is reduced! In the multicellular life stage of an animal or higher land plant, each cell has twice as many chromosomes as the unicellular stage (gamete). Production of the gametes requires reduction of the chromosome number during a special mode of cell division (meiosis). They are all either freed to the aquatic environment, or the flagellated gametes (sperm) are injected directly into the genital tracts of the other sex, where yolk-rich gametes without flagella (eggs) wait. As a result, they join together to form the zygote. The ensuing process of regular cell division (mitosis) leads to the formation of a colony of genetically identical cells that diversify as a result of the expression of different gene sets to develop functionally specialized organs. This process more or less precisely repeats the course of evolution from unicells to more and more complex multicellular organisms.

At the beginning of a multicellular organism life cycle there are cells functionally similar to protists – amoeba or flagellate. They may join to form a single-celled zygote or may not (if the organism is asexual). Also, human ontogeny follows this track and is virtually identical with that of our animal relatives. It takes much time to lose gradually the similarity to fish and reptiles, and until about the 32nd day of pregnancy the human embryo does not differ from that of an anatomically unspecialized mammal. Until the 5th week we have a tail like a monkey, although even apes lack any tail at maturity (Schultz 1969). Even at delivery the newborn brain has its cortex folding (which is a result of the faster growth of the external cortex layer than its internal parts; Tallinen et al. 2016) less complex than that of a mature ape, because the complexity of the gyri and sulci pattern depends mostly on the brain size. There are limits on the brain size at the moment of delivery imposed by the diameter of pelvic opening. The fossil evidence shows that painful delivery has been a problem for women for at least two hundred thousand years (Gruss and Schmitt 2015). As it appears, all the developmental transformations are gradual and there is no clearly recognizable point of ontogeny, at which the unique human aspects of anatomy emerge.

But there is one more aspect of humanity that gives a chance to find a clear distinction from animals. These are moral values. A sceptic may ask: moral values, or just behavioural adaptations? This is an attractive field for developing concepts of ‘evolutionary ethics’ based on the assumption that morality (and religion) is inherited with genes and evolves under the control of natural selection (for a review see Nitecki and Nitecki 1993). It is hard to dismiss this claim completely. Truly, much of our behavior is controlled by hormones (e.g. Heinrichs et al. 2009; De Dreu et al. 2011). But it is misleading to classify the herd instinct (nationalism, chauvinism, and xenophobia), territoriality (ownership) or family love (nepotism) among higher moral values. To be sure, in biological terms it is good to promote relatives, reject or even kill strangers, approve rape and promiscuity. ‘Evolutionary ethics’ may easily transform into social Darwinism.

Fortunately, one may see a spark of hope in the belief that the main ideas of morality emerged as a result of the action of a mechanism different from natural selection and genetics. The concept of the Darwinian evolution of ideas based on the mechanism of cultural selection offers such an alternative that is morally less damaging.

Evolution by Selection of Ideas

Such an alternative is offered by the ‘World 3’ concept of Karl R. Popper (1972). It refers to cultural analogies with the biological background of evolution that were noticed also by many other authorities: the transmission and replication of ideas is analogous to the heredity of the genome (DNA), and inventions and mistakes generate variability. The main difference between biology and sociology is that the free market evaluates and selects ideas, not the living beings that hold them. It seems rather obvious that the most important aspect of such evolution is the emergence of cultural novelties, the impact of scientific discoveries and technological inventions probably being most important. The effect of evolutionary novelties in the history of organisms is exactly the same. Obviously, the flow of ideas across society, and the fates of those ideas, are much more chaotic and complex than the flow of genes in organisms.

A straightforward application of biological theories to social processes would meet a lot of difficulties but at least in some aspects the analogy seems to be truly far-reaching, especially since the invention of writing systems, which improved storage and transfer of ideas. It is nicely exemplified by the 'phylogenetic tree' of alphabetic characters showing how they originated as a result of the simplification of hieroglyphs by changing their meaning (the first sound instead of the whole name) and graphic representation (Fig. 5.8). Their evolution was gradual and divergent. Its most apparent distinction from the phylogeny of species is that in biology the horizontal transfer of genetic information is negligible, but the flow of ideas between cultures may be more significant than their changes in isolation.

Probably the most important common aspect of both biological and cultural evolution is its cumulative nature. This is referred to as progress. Although it is difficult to define progress in strict scientific terms, intuitively it seems to correspond to the concept of 'negenthropy' of Erwin Schrödinger (1944). It is generated as unpredictable inventions (in culture) or evolutionary novelties (in biology). Selection is the main factor introducing 'negenthropy' to evolving systems. A nice example of a cumulative pattern of cultural evolution is that of political institutions of the Western world. What actually made this process so fast and efficient is a subject of continuing dispute. There are opinions that the mechanism was developed already at the stage of its evolution when the Indo-European tribes shepherding cattle somewhere on the eastern European steppe (Callaway 2015) voted by acclamation in their assemblies. In ancient Greece this was formalized, and equal rights were given to all citizens (Thorley 1996). The next step was taken in the Roman Republic by introducing the idea of representation of interests of voters (Crawford 1992; Taylor 1990). According to widespread belief, the crucial achievement of our civilization is the method of pacifying conflicts, which was invented by Christianity. In large European societies, democracy reviving after the Medieval epoch required a mutual control of its institutions. For this purpose the government was split into separately elected three branches in the sixteenth century Polish Commonwealth (Jędruch 1982). This evolutionary progress has resulted in the almost worldwide domination of European civilization. Ironically, its superiority is Darwinian in origin, but in non-biological terms.

Some institutions of advanced societies have been invented explicitly to contradict biology. This concerns also some aspects of family life, from which the whole history of humanity began. In ancient tribes and present-day traditional societies young women are in a sense the property of dominant males. This is an ancient

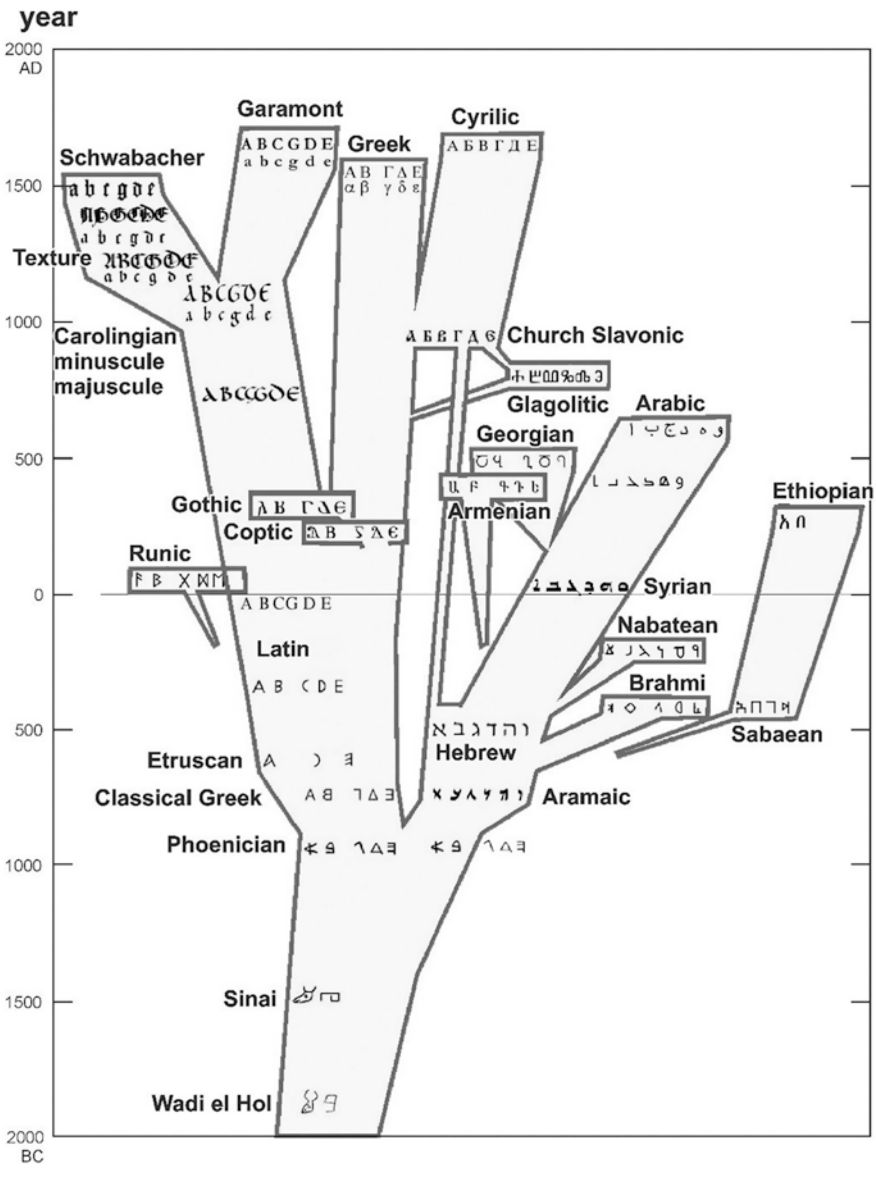

Fig. 5.8 Evolutionary tree of alphabets. First few 'homologous' (representing a continuity of information) letters in their conventional order are shown

behavioural trait inherited by humans after their animal ancestors. Monogamous marriage in its modern meaning originated and evolves as an institution protecting women and their children from such a biological legacy. At the Council of Trent in 1563 marriage was given the rank of a sacrament. There is no doubt that this regulation added safety to the lives of all members of the family. Such institutional inventions have much chance to survive and expand, promoting the expansion of associated cultural traits.

Conclusions

We have inherited a lot from our animal ancestors, but morality is mostly a novel part of human culture developed as a product of the Darwinian evolution of ideas. Apparently some moral principles are at the same time rooted in biologically determined instincts and in cultural tradition. Maternal and family love are among them, serving both as a measure of survival of the genome, in which they are coded, and as a support to the continuation and expansion of cultures that endorse them. But there are at least equally common cases of conflict between biology and culture.

To pacify such conflicts one has to weigh the profits to society from taking one of the possible choices. Acting in accordance with biologically-controlled behavior increases the chance of transferring one's individual genome contents to the next generation. It is clear that the genomes of ruthless soldiers of an invading army, who rape women and kill men, have a greater chance of spreading out and surviving than the genomes of peaceful members of the local population. Although in present-day Europe this is not considered moral, there are still societies that include the demand for such aggressive behavior in their moral systems. However, there are cases of individuals getting impressed so much with their enemy's culture as to change their behaviour. The institutions of a peaceful local society may offer profits which are more appealing, in terms of an evolutionarily stable strategy. A culture, like a virus, may survive the physical elimination of its creators if another population is meanwhile infected with it. This is a form of Darwinian evolution by selection, not imposed on the carriers of genetic information, but rather on ideas freed from the vehicles of their transfer.

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